The Muscular System

Chapter 10

Muscles

<table>
<thead>
<tr>
<th>Voluntary muscle</th>
<th>Involuntary muscles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Skeletal muscle fibers</td>
<td>1. Cardiac and Smooth muscle fibers</td>
</tr>
<tr>
<td>2. Attach directly or indirectly to bones</td>
<td>2. Are present in skin, heart or other visceral organs</td>
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<tr>
<td>4. Multinucleate on maturity</td>
<td>4. Uninucleate on maturity</td>
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</tbody>
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Functions of Muscles

1. Skeletal muscles are voluntary and perform
2. Produce movement of skeleton
3. Maintain posture and body position
4. Support soft tissues
5. Guard entrances and exits
6. Maintain body temperature

Bundle within bundle - organization of muscle
Muscle → fascicle → muscle cell or fiber
Covered by connective tissue covering
Epimysium → Perimysium → Endomysium
All 3 coverings join to form tendon of the muscle that joins it to a bone
Tendon is chord like and Aponeurosis is sheet like structure formed of regular dense connective tissue
Muscle cell → myofibril → thick and thin filaments
Thick filament – Myosin; thin filament – Actin, Tropomyosin, and Troponin

Anatomy of Muscle Cell 2

Binding site is present on each unit of Actin protein and myosin head process attaches to it for pulling the thin filament.
Terminal cisternae are sacs of Sarcoplasmic Reticulum (SR) and lie on each side of t-tubule. These store Ca^{2+} and release them on stimulation into cytosol of muscle cell.
Sarcolemma is the cell membrane of muscle cell.
T-tubules are invaginations of sarcolemma deep into muscle cell and carry wave of depolarization.
Each thick fiber is surrounded by 6 thin fibers; each thin fiber is surrounded by 3 thick and 3 thin fibers

Neuromuscular Junction

Nerve and muscle come together
Axon terminal – presynaptic membrane – synaptic cleft – postsynaptic membrane of motor end plate
Motor action potential reaches axon terminal
Acetylcholine released in cleft and binds to postsynaptic membrane
Action potential passes through:
Sarcolemma – t-tubule – terminal cisternae
Ca^{2+} released from terminal cisternae
Recap 1 – Muscles

1. Muscle → muscle fiber = muscle cell → microfilament → filaments.
2. Thin filaments is formed of actin, tropomyosin, and troponin.
3. Thick filaments are formed of myosin protein. Each myosin has processes to bind to filaments.
4. is a unit of contraction and lies between thick and thin filaments.
5. band has actin filaments and has line at its middle.
6. band has both actin and myosin filaments and has zone at its middle.
7. has only myosin filaments and has line at its middle.
8. Connective tissue covering complete muscle is, a fascicle is and muscle fiber is.
9. Axon terminal releases neurotransmitter in synaptic cleft

Microstructure of Muscle Cell

Thick filaments formed of Myosin lie at the middle (A-band) of sarcomere. The ends of thick filaments are joined to Z-line proteins through teatin protein strands.

Thin filaments have main protein Actin formed of 2 rows of globular units. Each unit has an attachment site for the head process of myosin; Tropomyosin protein that covers the attachment sites of actin; Troponin complex is attached periodically to tropomyosin and has sites for attachment of Ca²⁺. The attachment of Ca²⁺ to troponin moves the troponin-tropomyosin complex and exposes the attachment sites on actin.

Sarcomere is the unit of muscular contraction. It is the part between 2 successive Z-lines = Z-discs of the myofibril. Actin thin threads attach to z-disc at one end and are free at the other end.

Transmission of Nerve Impulse

Polarization or Resting Potential: When a nerve fiber is not conducting nerve impulse, it is Polarization, having 2 distinct poles. Also called resting potential, overall + ions dominate on the outside nerve fiber and – ions dominate inside it (-70mV).

Depolarization: When a nerve membrane is stimulated, Na⁺ ions move inside and now + ions dominate inside and – ions dominate outside (+35mV). It happens in immediate region and is Depolarization, opposite to polarization. The depolarization travels from dendrites to body to axon to axon terminals and is called nerve impulse or action potential.

Repolarization: When action potential reaches next region, the last region returns to resting potential.

Energy Utilization by Skeletal Muscles

At rest skeletal muscles use fatty acids and store glucose as glycogen

Skeletal muscles aerobically (use oxygen) break down glucose/glycogen/ amino acids/ fats and generate ATP during light activity.

During heavy activity skeletal muscles anaerobically break down glycogen and produce lactate

Activity and Muscle Mass

Activity or exercise increases # of myofibrils in a muscle fiber and result in their growth.

Inactivity on the other hand causes degeneration of myofibrils leading to shrinking of muscles.

Prolonged inactivity may induce replacement of muscle tissue by fibrous tissue.

Activity → ↑ muscle mass and inactivity ↓ it

Ageing → ↓ muscle mass and ↑ adipose tissue
Recap - 2 Muscles

1. Pre-synaptic membrane secretes neurotransmitter in synaptic cleft and result in depolarization of.

2. Depolarization wave travels from motor end plate to sarcolemma; carry it deep into muscle fiber and stimulate to release Ca$^{2+}$.

3. Ca$^{2+}$ ions enter into cytosol and join to thin filaments; it moves the complex covering the binding sites of.

4. Head process of binds to actin and loses releasing energy. This energy results in pivoting of head process and pulls the actin and therefore Z-lines towards the middle of sarcomere.

5. Joining of causes the release of head process; the partial oxidation of ATP into and once again bring the head process in cocked position.

6. is a group of muscle fibers innervated by same motor neuron and contracts and relaxes at same time.

7. is artificially induced single contraction and relaxation of a muscle fiber.

8. is sustained contraction of a muscle or its part due to series of fast stimulations.

9. contraction generates tension without change in length of muscle and contraction generates same tension but length of muscle varies.

Muscle Attachments

Origin – fixed or moves less
Origin is usually proximal
Insertion – moves more
Insertion is usually distal
During contraction usually insertion moves closer to origin

Muscle types on basis of action

Prime Mover – Agonist = main action - Masseter
Synergist helps the prime mover in action – temporalis
Antagonist is muscle with opposite action – Digastric

Recap 3 Muscles

1. muscle has 2 halves Frontalis and Occipitalis joined by epicranial

2. muscle help to keep food under teeth and also to generate air pressure needed to play a saxophone.

3. helps in grinning or smiling.

4. is a sheet like muscle of neck and helps in keeping the skin taught during shaving.

5. muscle contracts to cause extension and hyperextension of neck.

6. Major abductor of shoulder is muscle; its antagonists are , ,

7. and are main flexors of shoulder and is its antagonist and results in extension of shoulder.

8. Quadriceps femoris acts as thigh but knee muscle.

9. and lie in posterior compartment of leg and their contraction result in plantar flexion; their antagonist is

10. In arm biceps brachii is main elbow; synergist is; antagonist is